Integrated Modelling and Economic Workflow for Evaluating Viability of CCUS Project:

Investigating Implementing Real Case Study to KPC Fields

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OCT, 2023

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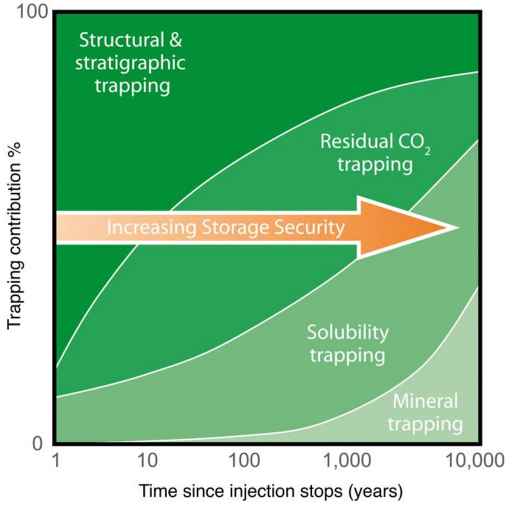
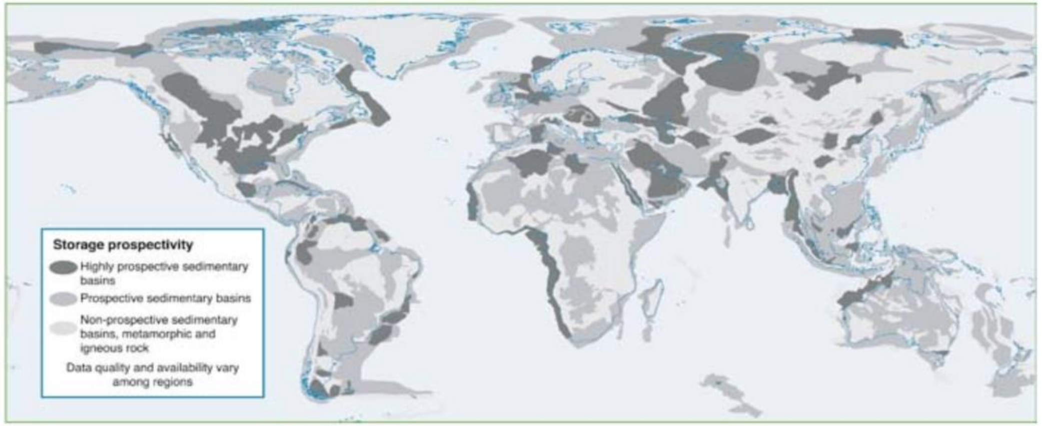
  - Potential Impact on Egypt's Energy Sector
- **Conclusion**

Introduction

- Carbon dioxide (CO_2) sequestration
- Its success depends on:
  - efficient sealing
  - no escaping from the storage
  - minimum corrosion to injection tubing/casing
- Different basins have been studied for the potential to store CO_2 in US, Norway and UK
- No qualitative and quantitative assessment have been made for other basins
  - Scotian Basin
- The assessment aim at achieving carbon neutrality by the year 2050



Percent contribution of different CO2 trapping mechanisms in underground formations as a function of time (IPCC, 2005).



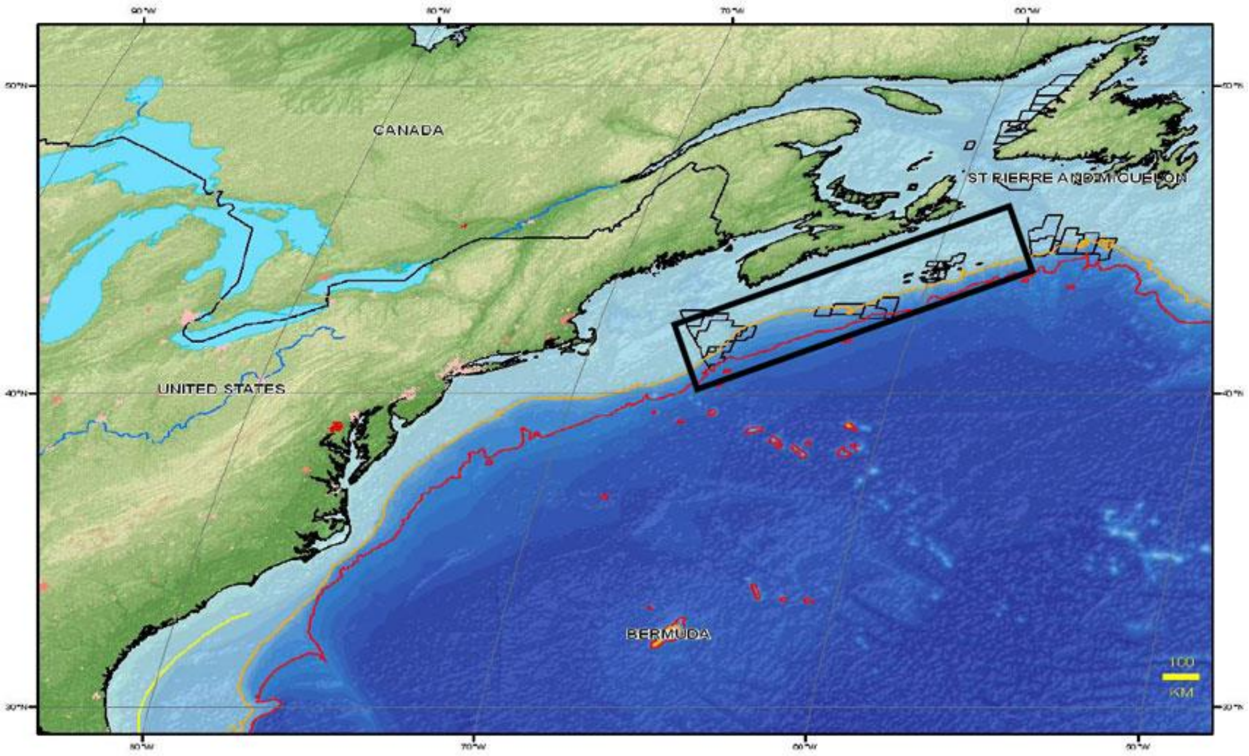
Prospective areas in sedimentary basins (IPCC, 2005)

Case Study: Scotian Shelf – Basin Overview

- **Location:** on the coast of Nova Scotia in Canada
- **Extension:** 1,200 km
- **Area:** 300,000 km^2

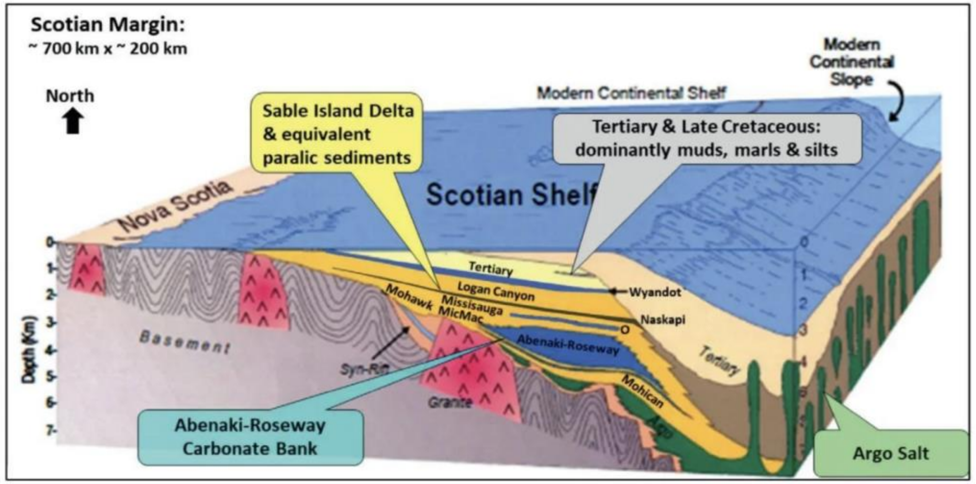
- It has history dating back to the breakup of the super continent

- Oil and gas activity spans for more than 50 years
  - ~200 wells
  - ~2.1 Bboe (Billion barrels of oil equivalent)



Case Study: Scotian Shelf – Basin Overview

- Monocline wedge of Middle Jurassic to Late Cretaceous sedimets
- These post-rift sediments were deposited as successive mixed siliciclastic-carbonate systems on a classic low-latitude passive margin
- High porosity-permeability aquifers (Abenaki and Missisauga)
- Capped by low permeability Late Cretaceous and Cenozoic mudstones and marls/chalks which provides a regional top seal
- **Many intra-formational seals:**
  - O ‘Marker’
  - Naskapi Shale



Case Study: Scotian Shelf – Methodology

Data Acquisition
Geological Maps
Seismic
Well Logging
Core Analysis
Production Data

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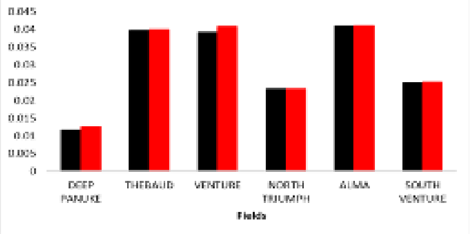
Data Analysis



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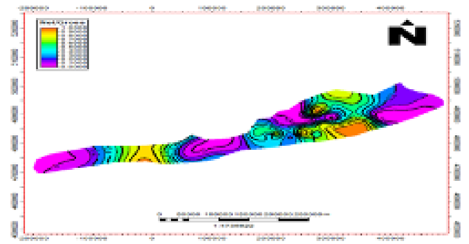
Reservoir Characterization



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Assess CO2 Storage Potential
Volumetrics in Deep Saline Aquifers of Scotian Shelf

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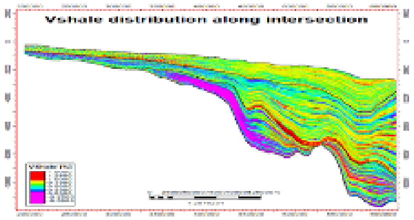
Seal Evaluation



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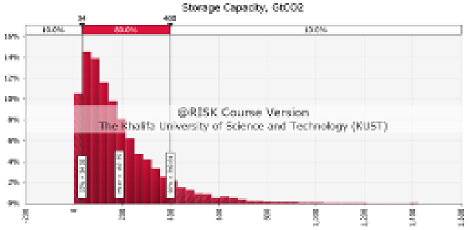
Risk Analysis



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Assess CO2 Storage Potential
Material Balance Equation in Depleted Fields

→

Surface Facilities
Monitoring System Design

→

Economic Analysis and Evaluation

Case Study: Scotian Shelf – Storage Options

Storage Options

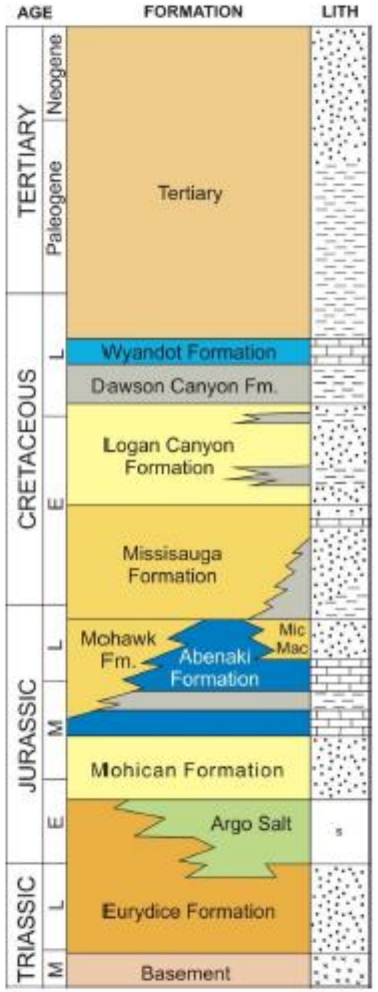
- Saline Aquifers
- Depleted Gas Fields
- Stranded Fields

Case Study: Scotian Shelf – Results and Findings

I. Saline Aquifers

- Assessment of volumetrics and Monte Carlo simulation
- Storage efficiency based on analogs from UK and Norway
- Estimates are:
  - Similar to the Atlantic margin off the Carolinas (Low, Average, High: 47,317,587 GtCO_2)
  - Smaller than the Gulf of Mexico (429, 3198, 5967 GtCO_2)
  - Higher than similar areas in the North Sea (45 GtCO_2, Norwegian Petroleum Directorate Atlas; 70 GtCO_2, CO_2STOR in the UK, Bentham *et al.*, 2014)

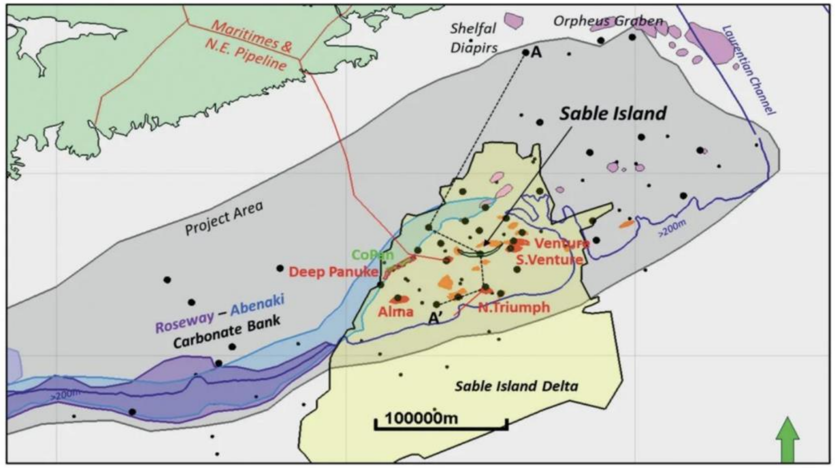
Formation	Avg Depth	Avg K	Open/Closed	Storage Efficiency	Sealing Formation	Storage Capacity, GtCO_2		
	(m)	(mD)				P90	P50	P10
Logan Canyon	2425	482	Open	4%	Sable Shale	34.26	187.35	399.64
Missisauga	4002	204	Open	4%	Naskapi Shale	58.59	430.60	979.16
Abenaki and Mic Mac	4211	344	Closed	0.8%	–	5.80	41.15	93.69

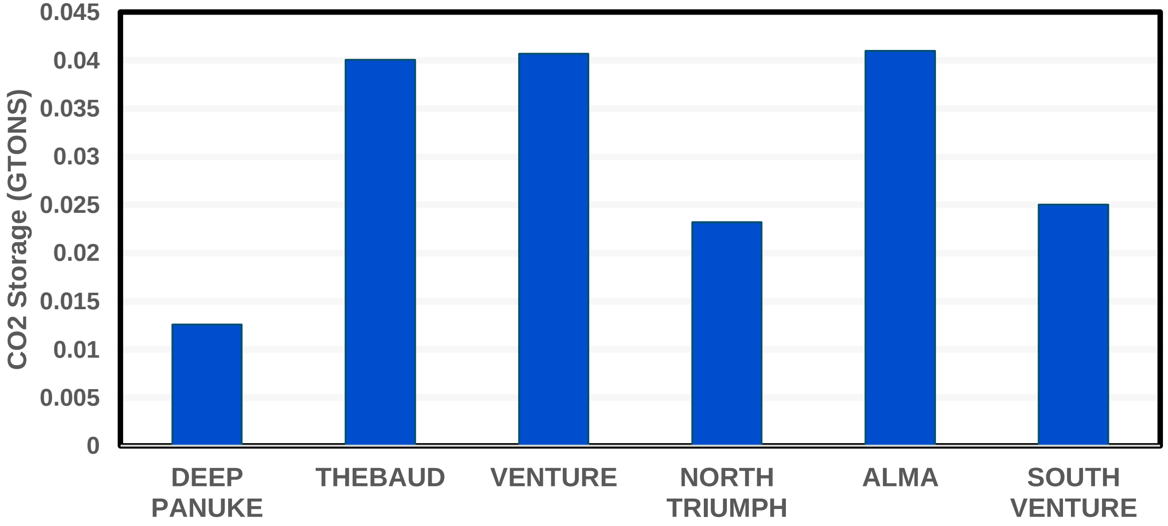


Case Study: Scotian Shelf – Results and Findings

II. Depleted Fields

- Five gas fields within the Sable Island Delta (Sable Gas Project)
  - developed and produced between 1998 and 2018 (2.1 TCF)
  - Decommissioned leaving an abandoned offshore pipeline that was connected to the onshore Maritimes and Northeast pipeline
- Two small oilfields (CoPan Project)
  - 44.5 MBO (1992 – 1999)
- Deep Panuke project
  - 147 BCF of gas (2013 – 2018)





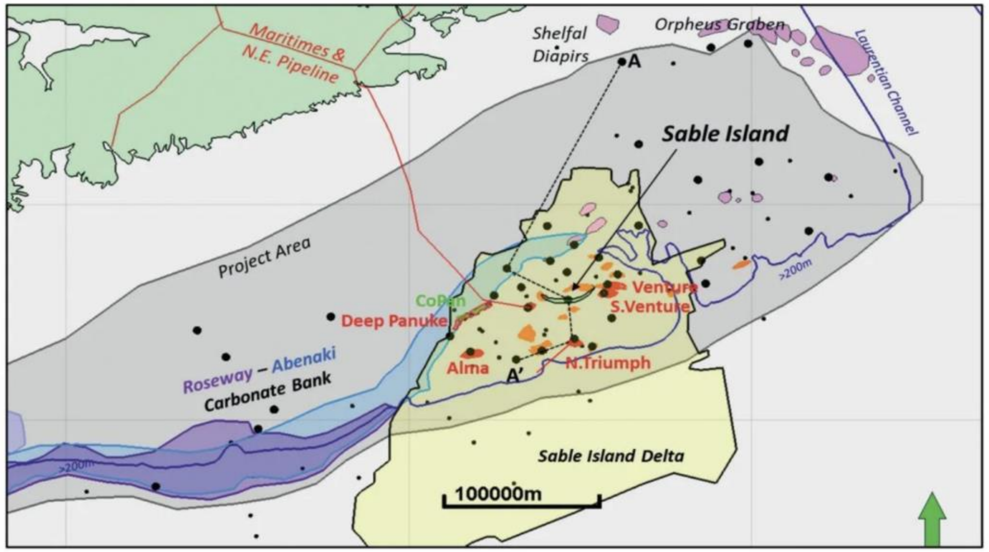
Case Study: Scotian Shelf – Results and Findings

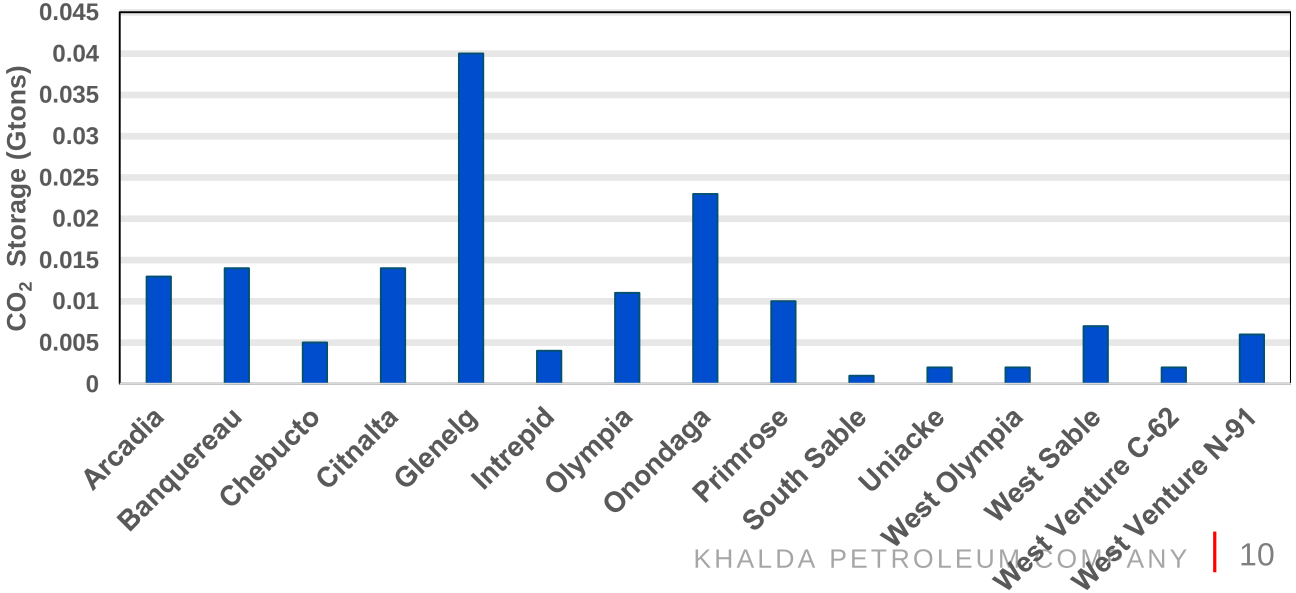
III. Other Depleted and Stranded Fields

- Carbon storage based on reservoir pore volumes calculated from produced (or producible) hydrocarbons

- A storage efficiency of 75% based on the 'IEA GHG 2009 Technical Study CO2 Storage in Depleted Gas Fields'

- Estimated 36 MtCO2,
  - Compares to much larger published estimates in North Sea fields (13 $GtCO_2$, Norway; 8 $GtCO_2$, UK)
  - A surprisingly low estimate in the Gulf of Mexico (15 $GtCO_2$).

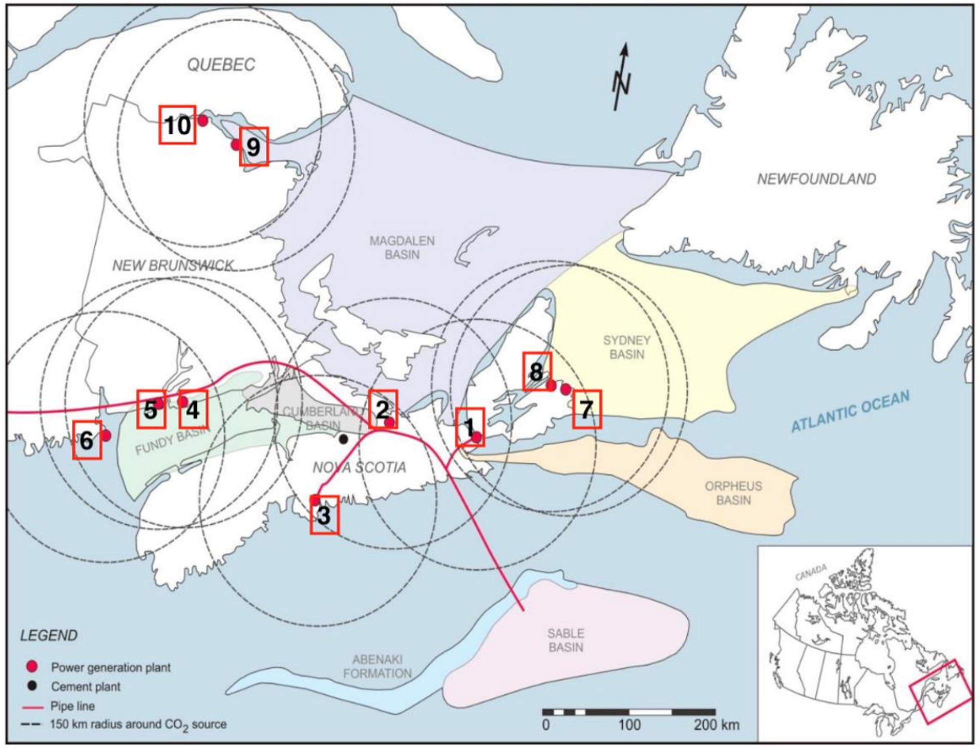




Case Study: Scotian Shelf – Results and Findings

Economic Analysis and Evaluation

- **10 Power generation plant have been identified**
  - Emitting around 12 Mtons of CO_2/Year
- **Lingan Power Plant**
  - The largest source of CO_2 emissions
  - Emitting around 4.8 Mtons CO_2/Year
- Around 0.36 Gtons of CO_2 released up to 2050
- Carbon credit will be earned 360$\times \mathbf{10^6}$

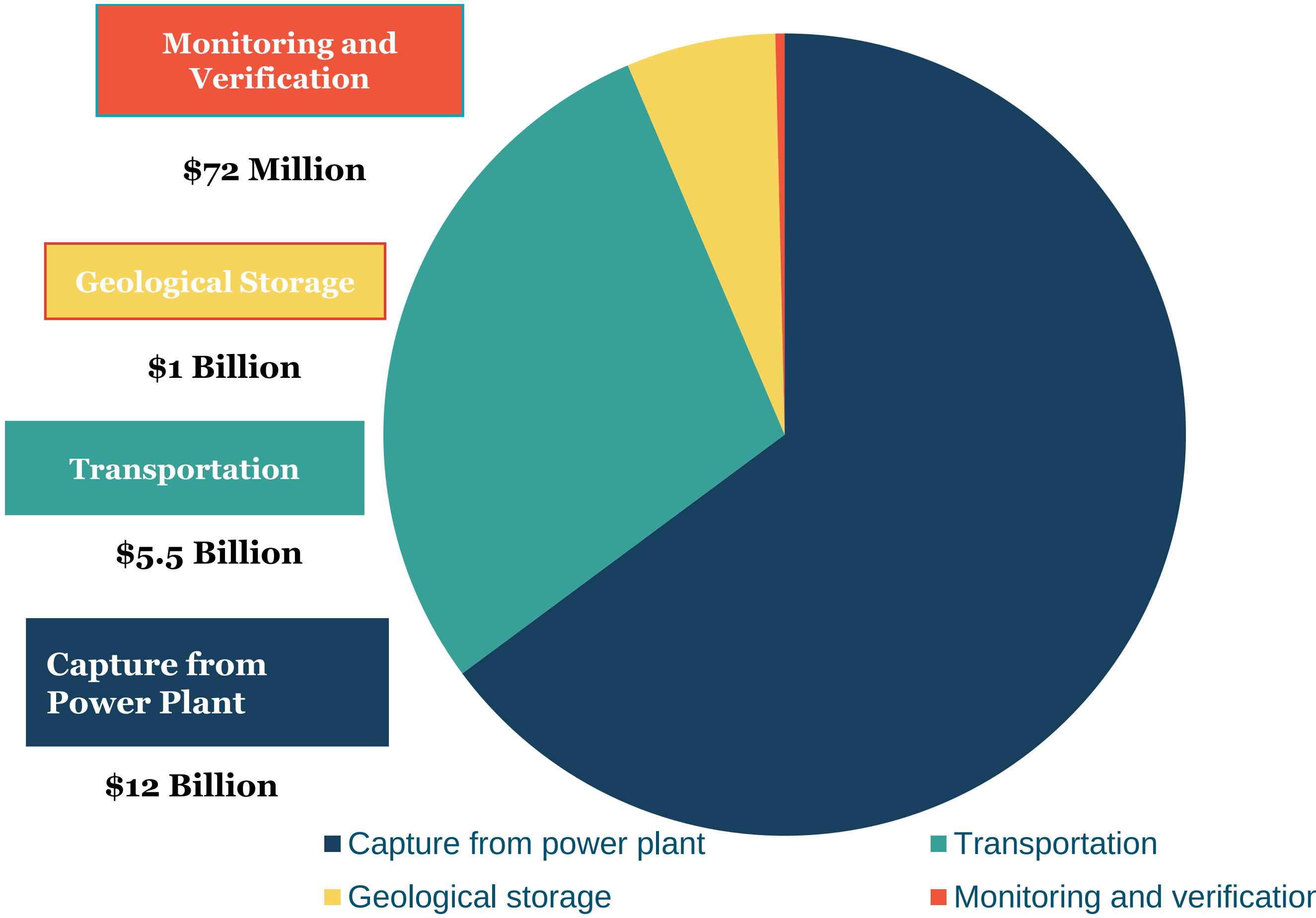


Location of Power Generation Plants

Case Study: Scotian Shelf – Results and Findings

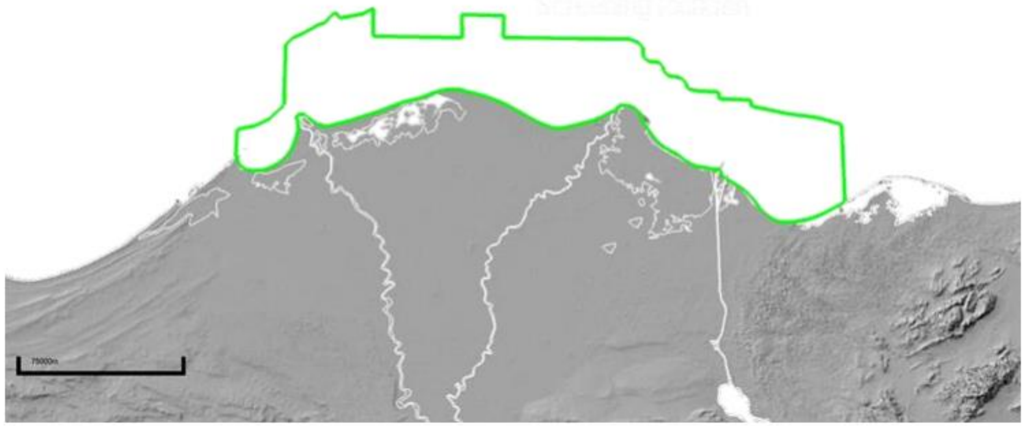
Economic Analysis and Evaluation

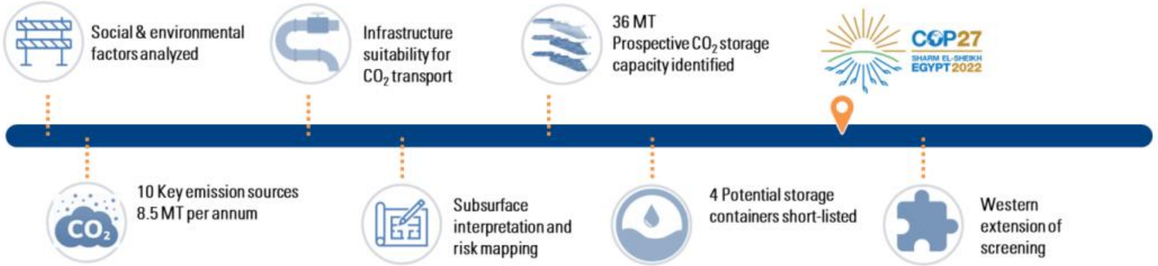
- The cost of the project $19.5 billion
- Carbon capture is the biggest hurdle
- $21.6 Billion undiscounted revenue from Carbon Credit
- **$2.1 Billion of undiscounted mean profit will be made**



Ongoing CCUS Evaluation Projects in Egypt

- Nile Delta CCUS
  - EGAS, EUG, Shell, and SLB
  - The study area is located in water depths of <100 m
  - Phase I, the project team collected the available data, assessed the storage capacity and subsurface risk for each potential site identified
- Meleiha CCUS
  - With Eni
  - pilot project —marks Egypt’s first carbon capture initiative — I
  - at a cost of USD 25 mn
  - aims to store some 25-30k tons of carbon dioxide each year






Sunday, 8 May 2022

Oil Ministry announces launch of Egypt’s first pilot carbon capture project with Eni + raft of other green energy initiatives

Opportunities for CCUS Implementation

- **Leveraging Existing Infrastructure**

  Egypt's well-established oil and gas sector provides a solid foundation for CCUS integration. Existing pipelines, facilities, and reservoir expertise can be repurposed for CO_2 capture and storage.

- **Enhancing Energy Security:**

  By mitigating emissions from its extensive fossil fuel operations, Egypt can reduce its carbon footprint and bolster energy security. This move aligns with global efforts to stabilize the climate.

- **Diversification of Energy Portfolio:**

  CCUS complements Egypt's growing commitment to renewable energy sources. Integrating CCUS with renewable energy projects can help balance intermittent energy generation and ensure a stable and reliable power supply.

Challenges and Considerations

- **Regulatory Framework:**

  Establishing a robust legal and regulatory framework is essential for the successful deployment of CCUS projects. This framework should encompass permitting processes, liability protocols, and long-term storage site management.

- **Public Awareness and Engagement:**

  Building public support and awareness is crucial for the acceptance and success of CCUS initiatives. Education about the technology's benefits and safety measures is essential.

- **Technological Expertise:**

  Developing local expertise in CCUS technologies, from capture to storage, is vital. Collaborations with international experts and organizations can facilitate knowledge transfer.

Potential Impact on Egypt's Energy Sector

- **Reduced Carbon Emissions:**

  CCUS can significantly decrease Egypt's carbon emissions, demonstrating the country's commitment to global climate goals.

- **Economic Opportunities:**

  The development of a CCUS industry can create jobs, stimulate innovation, and attract investment in research and development.

- **Global Leadership in Climate Solutions:**

  Egypt can position itself as a leader in sustainable energy practices within the region, attracting international partnerships and investments.

Conclusions

Based on the findings of this study, the following conclusions can be made:

- CO_2 sequestration in underground formations is a critical technique for mitigating climate change.
- Success hinges on factors like efficient sealing, prevention of leakage, and minimal corrosion.
- Thorough planning and a study of CO_2's reaction kinetics are imperative.
- This study utilized volumetric and material balance approaches to assess Scotian Shelf's carbon storage potential.
- While Scotian Shelf is recognized as a potential CO_2 storage site, it lacks a quantitative assessment compared to basins in Norway and the UK.
- Data acquisition, reservoir characterization, and capacity assessments were conducted for various aquifers and gas fields.
- Results indicate Scotian Shelf's immense capacity to store up to 660 $GtCO_2$, encompassing saline aquifers and gas fields.
- Implementation of this project holds the potential to generate a substantial US$2 billion profit.
- The potential for applying this methodology in Egypt, with its substantial oil and gas reserves, presents a significant opportunity for the country to play a leading role in global efforts towards carbon neutrality. Egypt's well-established energy sector and geological formations make it a viable candidate for successful CO_2 sequestration initiatives.

Acknowledgement

To **Dr. Bill Richards,** University of Delhousie, Canada

for providing the data and mentoring the work

To contributors from **KUST and ADNOC** for their significant input to the work

To **Maxim Mikhaltsev**, SLB for providing significant input about the current CCUS projects in Egypt

References

Cummings, D.I., Arnott, R.W.C. and Hart, B.S. [2006]. Tidal signatures in a shelf-margin delta. Geology, 34(4), pp.249-252.

Gammer, D., Green, A., Holloway, S. and Smith, G. [2011]. The Energy Technologies Institute's UK CO_2 storage appraisal project (UKSAP). *SPE Offshore Europe Oil and Gas Conference and Exhibition*, Society of Petroleum Engineers, Aberdeen, UK.

Guo, F., Aryana, S. A., Wang, Y., McLaughlin, J. F., & Coddington, K. [2019]. Enhancement of storage capacity of CO_2 in megaporous saline aquifers using nanoparticle-stabilized CO_2 foam. International Journal of Greenhouse Gas Control. 87, 134-141.

Metz, B., Davidson, O., De Coninck, H.C., Loos, M. and Meyer, L. [2005]. IPCC special report on carbon dioxide capture and storage. Cambridge: Cambridge University Press.

Piper, D.J., Pe-Piper, G. and Ingram, S.C. [2004]. Early Cretaceous sediment failure in the southwestern Sable Subbasin, offshore Nova Scotia. AAPG bulletin, 88(7), pp.991-1006.

Thomson, J. R. [2015]. High integrity systems and safety management in hazardous industries. Butterworth-Heinemann.

Wade, J.A. and MacLean, B.C. [1990]. The geology of the southeastern margin of Canada.

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